An Analysis of Higher Order Thinking Skills Based Errors Committed by Secondary Stage Students in Context of Streams and Gender

Synopsis

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Introduction

The reports of Programme for International Students Assessment (PISA, 2024); Annual Status of Education Report (ASER, 2024) National Education Policy (NEP, 2020) and National Curriculum Framework for School Education (NCFSE, 2023) have stressed on the importance of moving from a rote based system to one which requires students to use higher order thinking skills. This shift is crucial to fostering an educational environment where students not only receive information but also understand and apply their knowledge in various contexts, which is essential for their success in a continuing changing global scenario.

The key overall thrust of curriculum and pedagogy reform across all stages will be to move the education system towards real understanding and towards learning how to learn and away from the culture of rote learning as is largely present today (ASER, 2024). A fundamental role of education is to equip students with the competences they should have in order to succeed in society. Higher Order Thinking Skills can help them adapt to a constantly and rapidly changing world, and one that demands flexible workers equipped with '21st century' skills that go beyond core literacy and numeracy (ASER, 2024). The students may likely be employed in sectors or roles that do not yet exist, using new technologies to solve novel problems. Education for higher order thinking can help students to adapt and develop the capacities to undertake work that cannot easily be replicated by machines and address increasingly complex local and global challenges with out-of-the-box solutions (Hitchcock, 2020). Higher Order Thinking Skills are crucial for every academic stream. ASER (2024) has reported the distribution of students enrolled in different streams. This survey was conducted on 34745 students of 28 districts across 26 states. It was reported that the majority of students in the age of 14-18 years tend to enroll in the Arts/Humanities stream, with over half (55.7%) opting for it at secondary level, followed by STEM (Science, Technology, Engineering and Mathematics) which attracts 31.7% of students, and only 9.4% students opted Commerce. After completing secondary education/ graduating, students from different streams participate in various competitive examinations at both the national and state levels, including those administered by the Staff Selection Commission (SSC) and State Public Service Commission (SPSC), Indian Railways, Union Public Service Commission (UPSC) etc. where they are assessed on the same platform.

According to the UPSC report (2023), the number of candidates who qualified the mains examination and appeared for interview was 2,049 in 2020. The success rate of candidates from science background was highest with the rate of 76.12%. The success rate of candidates from arts/humanities was 19.5%, whereas commerce students were at the least who cleared this examination with 4.38%. As per the data from the Civil Services Exam (CSE) conducted between 2011 and 2020 indicates a significant shift in the educational backgrounds of selected candidates (Singh, 2023).

The proportion of candidates with an engineering background has increased from 46% in 2011 to 65% in 2020. Conversely, the percentage of candidates with a medical background has declined from 14% in 2011 to 4% in recent years. The percentage of candidates with humanities background who qualified the CSE (Civil Services Exam) varies between 23% and 28%, the only exception was in 2012 when 40% were from the humanities. (Ghosh, 2023, p. 2).

From 2017-2021, the total no. of candidates qualified for mains UPSC civil services exam was 59154. The data revealed that 4371 candidates cleared the Mains examination with 3098 from science, 1033 from humanities and 240 from medical science. The number of candidates recommended for the mains in 2017, 2018, 2019, 2020, and 2021 were 1056, 812, 922, 833, and 748, respectively. In terms of Gender, 3,635 male candidates (constituting a total of 74.6%) and 1106 female candidates (constituting a total of 25.4%) had cleared the exam between 2017-2021. In 2022, Out of 933 candidates 613 men and 320 women have been recommended by the Commission for appointment to various services (Press Information Bureau, 2023, p. 2).

The data indicates that there is a difference on the basis of streams and gender who have cleared this examination. Higher Order Thinking Skills based questions are prevalent in these examinations (Ministry of Education, 2024). However, it is important to acknowledge that other factors may also influence the performance of students on questions based on higher order thinking skills like classroom environment, psychological and intellectual characteristics of students. These factors have direct effects on higher order thinking skills whereas, the hereditary characteristic had indirect effects on higher order thinking skills through psychological characteristics (Budsankom et al., 2015). The curricular and extra-curricular activities, assessment patterns of different school boards may also be one of the causes of variation in development of higher order thinking skills.

An insufficient number of higher order thinking skills based questions in examinations can also be a cause that affects the development of students' higher order thinking skills. It indicates that students do not engage in proper practice with higher order thinking skills based questions that hinders the development of these abilities. The percentage of questions on higher order thinking skills vary among different educational boards. The Central Board of Secondary Education (CBSE) includes only 15% of questions which are related to higher order thinking skills in their terminal examination whereas other boards such as ICSE includes 20 to 30 percent of such questions (Grewal, 2024). It reflects that the percentage of questions based on higher order thinking skills in schools is much less in comparison to questions based on Lower Order Thinking Skills (LOTS). This leads to insufficient exposure to questions based on higher order thinking skills.

Higher Order Thinking Skills play a critical role in fostering cognitive development and preparing students for complex problem solving and decision-making tasks. The target of every academic stream is to develop higher order thinking skills in students which prepare them for their future academic and professional benefits (Harta et al., 2020; Karunarathne & Calma, 2024; Bryant, 2017). For instance, in the science stream, where problem solving and analytical abilities are foremost, a higher proportion of higher order thinking skills based questions might be deemed necessary to adequately prepare students for future scientific endeavours (Harta et al., 2020). In the commerce stream, where analytical skills are still essential, there may be a greater emphasis on practical application and understanding of concepts of higher order cognitive processes (Karunarathne & Calma, 2024). In the arts stream, where creativity and critical analysis often intersect, the inclusion of higher order thinking skills based questions could foster deeper engagement with the subject matter and encourage students to think critically about complex issues (Bryant, 2017).

But, are the required skills being developed to the desired extent? If the required skills are being developed as stipulated, one would expect to see this progress in assessments such as ASER (Annual Status of Education Report) and PISA (Programme for International Students Assessment) results. However, the report of ASER (Annual Status of Education Report) indicates that even Minimum Learning Outcomes (MLO) are not achieved as per the target. One of the reasons can be untreated errors committed by students while solving questions. Furthermore, even students who have met the MLOs

(Minimum Learning Outcomes) may still lack higher order thinking skills, while others struggle even more with higher order thinking skills based problems. This suggests that students face difficulties with tasks related to higher order thinking skills (Abdullah et al., 2015).

Higher Order Thinking Skills Based Errors

Higher Order Thinking Skills are used in research to describe some form of complex thinking that demands high cognitive processes (Musliha et al., 2021). Higher Order Thinking Skills are defined as thinking that occurs "when a person takes new information or stored in memory interrelates or rearranges this information to achieve a purpose and find possible answers in perplexing situations" (Mitani, 2021). Higher Order Thinking Skills includes evaluation or judgment, problem solving, as well as creative thinking, and decision making (Mitani, 2021). Since Higher Order Thinking Skills results from a merger of the two different perspectives on critical thinking, it also includes broadly defined critical thinking as its component. Reasoning or productive thinking is part of problem solving, as it is used to integrate past experiences that have not been associated to find a solution to a novel challenge (Zohar & Dori, 2003).

Schraw et al. (2011) view Higher Order Thinking Skills as thinking skills composed of reasoning, argumentation, problem solving and critical thinking, and metacognition. Brookhart (2010) defines Higher Order Thinking Skills in terms of transfer (i.e., making sense of and being able to use what one has learned), critical thinking, and problem solving. The underlying mechanism across these components is relational or analogical reasoning, which is the process of representing information and objects in the world as systems of relationships, such that these systems of relationships can be compared, contrasted, and combined in novel ways depending on contextual goals (Richland & Simms, 2015).

Higher Order Thinking Skills refer to a concept based on learning taxonomies such as Bloom's Taxonomy and its revised version by Anderson and Krathwohl (Kuloglu & Tutus, 2024). Higher Order Thinking Skills involve learning processes that go beyond basic observation, memorization, and recall of facts. These encompass more complex judgments which include critical, logical, reflective, metacognitive, and creative thinking. Higher Order Thinking Skills are often seen as skills that are necessary for problem solving and understanding complex concepts, allowing students to analyze,

evaluate, and create new ideas rather than just remember information. In the context of Bloom's Taxonomy and the revised taxonomy by Anderson and Krathwohl (2001), Higher Order Thinking Skills are associated with the higher levels of the cognitive domain, which include:

- Analysis: Breaking down information into parts to understand its structure.
- Evaluation: Making judgments about the value of information or ideas.
- Creation: Combining elements to form a new coherent or functional whole.

When an individual commits errors while analyzing, evaluating, or solving problems using any form of creation, it leads to errors in solving questions based on higher order thinking skills (Anugrah et al., 2020).

According to Abdullah et al. (2015), Higher Order Thinking Skills based errors often stem from issues in logic, definitions, formulae, and technical aspects, occurring at various learning stages. These include encoding errors, where students misinterpret complex problems; process skills errors, where logical steps are flawed; transformation errors, where incorrect method or strategies leads to errors; and comprehension errors, where the concept of solving problems is misunderstood (Hadi et al., 2018). According to Cheng (2012), error analysis is a method frequently used to pinpoint the source of students' faults when they make the same mistakes again and again. Error analysis can be considered as a key element to find out problems and provide remediation for them (Jha, 2012). The errors committed by students represents an idea whether the students have understood the content or not and up to what extent have they understood the logic to solve a problem. Once these errors are identified, the source of errors can also be investigated and accordingly remediation may be provided (Winarso & Toheri, 2021). Analysis of students' mistakes in solving problems aims to know the difficulties experienced by students so that improvements can be made in the future (Rushton, 2018). Using Newman Error Analysis (NEA), teachers can identify errors and then plan effective and appropriate teaching strategies to address students' errors (Lopez, 2008; Rushton, 2018).

Analysis of Errors using Newman's stages of error development is as follows:

Reading Error - The first stage which is reading and decoding refers to the inability of the students in reading the problem given and determining the words or symbols given in questions (Musyadad, 2021).

Comprehension Error - In this error, the learners have the inability to understand how words are used

in different contexts in order to understand what is being read (Aziza & Eratika, 2022).

Transformation Error - In this error, the students could not find a suitable method or strategies to solve a problem (Jha, 2012).

Process Error - A process error occurs when students fail to perform the procedure correctly (Abdullah et al., 2015). If a student is unable to follow the correct procedure, it results in a process error (Hadi et al., 2018).

Encoding Error - In this error, the students do not write the final answer in an appropriate way or conclude it in an unacceptable manner (Wiens, 2007).

Streams

A stream is a series of area-specific courses that students' take as part of their degree (Prashad & Qasim, 2021). It allows them to specialize in a particular field of study. As per National Curriculum Framework for School Education (NCFSE, 2023), at the secondary stage, subject choices diversify greatly, and students can choose particular subjects or vocations to pursue, depending on the desired career or academic path. Previously, students were required to select their academic streams in a restricted manner. For example, the science stream typically included subjects such as physics, chemistry, and mathematics/biology; the arts/humanities stream included subjects such as history, political science, geography etc.; and the commerce stream included subjects like business studies, accountancy, and business economics. The National Education Policy (NEP, 2020) suggested that there will no longer be a 'hard separation' between arts and sciences or between vocational and academic streams. As per National Curriculum Framework for School Education, 2023 there is a set of subjects which students can opt according to their choice from subjects available in the school. In addition to science, arts and commerce various vocational subjects, arts & crafts-based subjects, physical education, wellbeing-based subjects and interdisciplinary subjects will be incorporated throughout the school curriculum, with a consideration for what is interesting and safe at each age (National Education Policy, 2020). According to the Central Board of Secondary Education (CBSE, 2024-25) students will be allowed to make subject choice in Class 11 based on provided lists of subjects. Previously, the lists of subjects were restricted to the streams such as science, arts/humanities and commerce. Now, the education board has shown more flexibility in the new policy regarding choosing subjects. According to National Education Policy (NEP,

2020); National Curriculum Framework for School Education (NCFSE, 2023) students can choose various sets of subjects as per interest.

As per National Curriculum Framework for School Education (NCFSE, 2023) students will choose two compulsory languages with some sets of subjects, these set of subjects will define their streams for example- if a student opts Business Studies, Accounting, Economics it will be commerce stream; if a student select Physics, Chemistry, Mathematics or Biology it will be science stream; if a student choose History, Economics, Psychology, Geography, Political Science it will be arts stream.

Professions require specific knowledge and skills that are typically acquired through the study of particular subjects. For example, aspiring doctors need a strong foundation in biology and chemistry, while engineers benefit from mathematics and physics expertise. On the other hand, chartered accountants are required to study subjects such as accounting, business studies, and applied business economics. Thus, students interested in these professions may choose subjects aligned with their career goals to build a strong educational foundation.

Science Stream*:* The science stream includes subjects such as Physics, Chemistry, Mathematics, and/or Biology. With this stream, students can pursue disciplines such as engineering, medical, pharmacy, and pure sciences (Rastogi, 2023).

Commerce Stream*:* The commerce stream includes subjects such as Business Economics, Business Studies and Accountancy. The commerce stream is suitable for students who want to pursue a career in areas like finance, accounting, or business management.

Arts Stream*:* The Arts stream includes subjects such as History, Geography, Political Science, Sociology, Psychology etc. The Arts stream is suitable for students who want to pursue a career in literature, humanities, or creative fields such as music, dance, or theatre etc.

The impact of educational streams (Arts, Commerce and Science) and gender on various types of errors which are based on higher order thinking skills is a complex and multifaceted issue with far reaching implications. This research will seek to identify the errors (comprehension error, transformation error, process error and encoding error) students commit while solving questions based on higher order thinking skills. This study will find out the similarities and disparities in the context of educational streams and gender. Through a comprehensive analysis of these relationships, educators can work to

reduce errors, enhance quality and promote more equitable learning outcomes for all students.

Gender

Gender based differences in academic performance have been a subject of ongoing scholarly discourse (Parajuli & Thapa, 2017). According to Hamid and Shukri (2014), Gender refers to the complex interplay of biological, social, and psychological factors that influence an individual's understanding and experience of themselves as male & female. Gender is a term that has a psychological or cultural meaning rather than a biological one (White & O'Connor, 2021). According to Bhasin (2014), Gender refers to socio-cultural definition of male and female, the way society distinguishes between men and women and assigns them social roles. If the proper terms for sex are male and female, the corresponding terms for gender are 'masculine' and 'feminine' (Stoller, 2020). Gender role is the behavior that a person displays in society, the role in which a person plays to establish his status with other people (White & O'Connor, 2021).

As highlighted by the Organisation for Economic Co-operation and Development (OECD, 2009), a deeper understanding of students' higher order thinking skills can be achieved by examining gender differences. It has also been reported that there is a difference in aptitude of solving problems between boys and girls (Carr & Jessup, 1997). However, findings on this matter are still inconclusive (Suseelan et al., 2021). For instance, Leder (2019) reported a slight gender difference favouring boys in complex problem solving. In contrast, Pang & Seah (2020) and Thien (2016) found that girls performed better in context-based word problems in the Programme for International Student Assessment (PISA, 2016). On the other hand, some researchers have suggested there is no gender difference in problem solving (Hyde et al., 1990).

Emergence

Higher Order Thinking Skills are now the focus of 21st-century education, aimed at enhancing analyzing skills, evaluative skills and creating skills (Shanti et al., 2022). A report by the World Economic Forum (2015) indicated a gradual increase in jobs demanding nonroutine interpersonal and analytical skills, whereas jobs requiring routine manual and cognitive skills have steadily declined between 1960 and 2010. The World Economic Forum (WEF) 2020 has released a report that underlines the importance of higher order thinking skills, such as analysis, evaluation, and creation, for effective functioning in the

modern world (World Economic Forum, 2020). By 2025, Higher Order Thinking Skills are expected to be essential, as the global demand for individuals will increase with strong analytical, evaluative, creative, problem solving, and critical thinking abilities (Mitani, 2021). However, not all students possess the necessary skills, and many struggle due to unrecognized and unaddressed errors that hinder the development of higher order thinking skills. It is observed that students face difficulties while solving questions based on higher order thinking skills in weekly tests and terminal examinations. These errors, as noted by Rushton (2018) and Herholdt & Sapire (2014), are often the primary sources of anxiety and obstacles in solving higher order thinking skills based problems. The National Education Policy (NEP, 2020) emphasizes the need for various modes of exams to foster higher order thinking skills in students, aligning with the 21st century skills of critical and creative thinking (Er. et al., 2020; Brightwell et al., 2004; Ashri & Sahoo, 2021). This approach promotes holistic development and discourages the traditional methods of rote learning and coaching culture, encouraging students to apply their knowledge to real world scenarios (Wattal, 2024). The CBSE (Central Board of Secondary Education) board included only 15% of questions which are related to higher order thinking skills in their terminal examination whereas other boards such as ICSE included 20 to 30 percent of such questions (Grewal, 2024). Now, The Central Board of Secondary Education (CBSE) has announced plans to adopt open book examinations for students in classes 9 to 12. Educational experts advocate for open book exams, which challenge students to use their analytical and problem-solving abilities rather than relying solely on memorization. Open book examination is mainly based on higher order thinking skills and a student may also commit errors in this mode of exam.

There can be similarities or differences found in errors committed by students of different streams. It is observed that there are many stream free entrance and competitive exams such as Staff Selection Commission - Combined Higher Secondary Level (SSC CHSL), Railway Recruitment Board Non-Technical Popular Categories (RRB NTPC), Common University Entrance Test (section 1 and section 3), Indian Air Force Airman Group Y (Non- Technical), army wing of NDA (National Defence Academy), Agniveer exam, state exam like Uttar Pradesh Subordinate Services Selection Commission -Preliminary Eligibility Test (UPSSSC- PET), Uttar Pradesh Subordinate Services Selection Commission (UPSSSC) Panchayat Sahayak etc. which assess students of different streams on the same

criteria. These exams include higher order thinking skills based problems which identify the evaluative, logical reasoning, comprehension ability, problem solving ability, data interpretation skills etc. of an examinee. Thus, it is required to conduct a research study which assesses these errors and become a foundation to provide equitable opportunities to learners and help them to succeed in exams.

Gender can also influence the types of errors made in higher order thinking skills. Research suggests that male and female students may approach learning and problem solving differently (Carr & Jessup, 1997). Higher order thinking skills based errors often stem from a lack of deep understanding or the inability to apply concepts effectively. It is observed that errors can manifest differently depending on the gender and the student's stream background. These differences may lead to distinct error patterns based on the subject and gender. By conducting error analysis across different streams and genders, researchers can identify patterns and trends in students' performance.

Error analysis can be helpful in finding out the root cause of inability of students to solve problems based on higher order thinking skills, which create hurdles between the students' learning and their achievements. These errors have an impact on students' academic performance (Lindberg et al., 2010). This analysis of errors and misconceptions highlights the need for more study to develop pedagogies that are more in line with the needs of the twenty-first century (Kotze, 2018). It is reported in various studies that students struggle to solve problems, especially those related to higher order thinking skills, which creates misconceptions in their minds (Suseelan et al., 2022; Huang et al., 2022; Dumitru, 2019; Tolba & Al-Osaimi, 2023). This understanding allows teachers to select appropriate teaching methodologies that help address the challenges faced by students. Such an approach can help to reduce higher order thinking skills based errors and ensure a more equitable and effective learning experience for all students.

There are various studies that examine students' errors in different subjects and contexts (Nelson & Powell, 2017; Rushton, 2018; Priyani & Ekawati, 2018; Ay, 2017; Herholdt & Sapire, 2014). Previous studies also suggested that errors should be broken up into smaller parts so that they can be understood at a different level (Cheng, 2012). These flaws may be systematically examined, and a remedy can then be offered. Whether educational streams and gender disparities have an impact on higher order thinking skills based errors will be analyzed through this study. Hence, the present study is proposed to identify

and analyze higher order thinking skills based errors that are committed by students in different streams and to study whether gender differences affect such errors at the secondary stage. It will discover the types of errors that students commit in solving higher order thinking skills based problems. The research questions that will be addressed in the present study are as follows:

Q.1- What are the higher order thinking skills based errors committed by students at secondary stage?

Q.2- What is the impact of academic streams on the higher order thinking skills based errors committed by students at secondary stage?

Q.3- What is the impact of gender on the higher order thinking skills based errors committed by students at secondary stage?

Q.4- What is the interactional effect of streams and gender on the higher order thinking skills based errors committed by students at secondary stage?

Justification

At the secondary stage, students have to take a pivotal step of choosing a stream (such as commerce, arts, or science), setting the foundation for their future academic and professional pursuits. After secondary education, students face various competitive and entrance exams that require higher order thinking skills, where many students commit errors due to a lack of proficiency in these crucial skills. There are previous studies that suggest students commit errors at various levels of education (Egodawatte, 2011; Cheng, 2012). Students commit errors that create a gap between their higher order thinking skills and their achievements. In order to rectify the errors, it is essential to identify the errors committed (Mohyuddin & Khalil, 2016). This study will help students to identify errors, and ultimately improve learning outcomes. This research study will help teachers to develop remedial programs for students after diagnosing errors based on higher order thinking skills. Teachers can modify their instructional strategies to address specific areas of concern, enhance the quality of education, and correct errors that hinder higher order thinking skills. This can be achieved by understanding how academic streams (Arts, Commerce and Science) influence the frequency and types of errors committed by students. The research study will also reveal the types of errors committed by different genders and provide recommendations for ensuring equal educational opportunities for all students. Errors that remain unaddressed can lead to persistent misconceptions that hinder students' progress in subsequent

years. Addressing and rectifying these errors at an early stage can pave the way for a stronger foundation and better academic achievement in the long run (Herholdt & Sapire, 2014). The awareness of errors enables educators to find solutions and provide assistance and support in areas where their children may struggle (Sepang & Sirola, 2013). By having empirical data after identification on higher order thinking skills based errors such as comprehension error, transformation error, process error and encoding error, educators will be able to make more logical decisions that can positively impact student learning outcomes. The study will help parents to understand higher order thinking skills based errors that their children commit. Once the errors are identified, students will be able to solve questions based on higher order thinking skills. This will not only improve their success in competitive exams but also help in actually developing higher order thinking skills as suggested in NEP (National Education Policy) 2020. While there are existing researches (Egodawatte, 2011; Wiens, 2007; Chongo et al., 2020; Nelson & Powell, 2017; Tong & Loc, 2017) on analysis of errors at the foundational, middle and secondary stage, the specific influence of educational streams and gender on higher order thinking skills based error is relatively an underexplored area. This research can contribute to the existing body of literature by analyzing this crucial aspect of the secondary stage in analyzing errors based on higher order thinking skills. Education stakeholders, including students, teachers, schools, administrators, policymakers, and parents can then make informed decisions. In the present study, an analysis of higher order thinking skills based errors committed by students in the context of streams and gender at the secondary stage can provide insight to identify, evaluate, and rectify higher order thinking skills based errors which will improve educational outcomes.

Statement of the Problem

An Analysis of Higher Order Thinking Skills Based Errors Committed by Secondary Stage Students in Context of Streams and Gender.

Definitions of the Variables

Higher Order Thinking Skills Based Errors According to Hadi et al. (2018), students' errors in solving Higher Order Thinking Skills problems can be categorized into four types: encoding errors, process skills errors, transformation errors, and comprehension errors also students struggle with relating information and implementing strategies to effectively solve higher order thinking skills test items.

Operational Definition- For the present study, Higher Order Thinking Skills based errors are defined as comprehension, transformation, process, and encoding errors committed by students while solving problems based on higher order thinking skills (analyze, evaluate and create).

Streams

According to Britton et al. (2022) A stream is a series of area-specific courses that students' take as part of their degree which allows them to specialize in a particular field of study.

Operational Definition- For the present study, Streams in the educational context, are distinct academic paths offering specialized areas of study such as Science, Commerce and Arts.

Gender

According to Hameed & Shukri (2014) Gender refers to the complex interplay of biological, social, and psychological factors that influence an individual's understanding and experience of themselves as male and female.

Operational Definition- For the present study, Gender refers to identification of individuals on the basis of masculine and feminine.

Objectives

1. To analyze higher order thinking skills based errors committed by students at secondary stage.
2. To analyze higher order thinking skills based errors committed by Arts stream students at secondary stage.
3. To analyze higher order thinking skills based errors committed by Commerce stream students at secondary stage.
4. To analyze higher order thinking skills based errors committed by Science stream students at secondary stage.
5. To compare higher order thinking skills based errors committed by students of Arts, Commerce and Science stream at secondary stage.
6. To analyze higher order thinking skills based errors committed by Boys at secondary stage.
7. To analyze higher order thinking skills based errors committed by Girls at secondary stage.
8. To compare higher order thinking skills based errors committed by Boys and Girls at secondary

stage.

9. To study the interactional effect of streams and gender on the higher order thinking skills based errors committed by students at secondary stage.

Hypotheses

H_{o1}: There will be no significant impact of streams (science, arts, commerce) on the higher order thinking skills based errors committed by students at secondary stage.

H_{o2}: There will be no significant impact of gender on the higher order thinking skills based errors committed by students at secondary stage.

H_{o3}: There will be no significant interactional effect of streams and gender on the higher order thinking skills based errors committed by students at secondary stage.

Variables of the Study

***Independent Variables*-** Streams (Arts, Commerce, Science) and Gender

***Dependent Variable*-** Higher Order Thinking Skills based Errors

Delimitations of the study

- The research study will be delimited to the secondary schools' students of Agra District only.
- The study will be delimited to the dimensions of Higher Order Thinking Skills i.e. analyze, evaluate and create (revised Taxonomy of Bloom cited by Anderson and Krathwohl, 2001).
- This research will be delimited to four errors- Comprehension error, Transformation error, Process error and Encoding error.
- The study will be limited to male and female students only.
- The study will be delimited to students in Class XI and XII.

Methodology

Research method

In the present study ***Descriptive Survey Method*** will be used to analyze the higher order thinking skill based errors of the students in different streams (arts, commerce and science) and to study the impact of gender on the errors committed by secondary stage students while solving questions based on higher order thinking skills. This method will allow the researcher to collect data from a number of participants, making it suitable for studying variations across different groups such as students from different streams

(Arts, Science and Commerce) and gender.

Population:

The population of the present study will be secondary school students (Class XI and XII) of Agra district. The researcher selected Agra District due to its accessibility and feasibility. Being locally based, the researcher can easily coordinate with schools, ensuring smooth data collection and regular visits. Agra's diverse school population provides a representative sample for gender and stream based analysis, while its proximity reduces logistical, financial, and time-related challenges, making it an efficient and practical choice for the study.

Sample Selection

For sample size estimation, a priori power analysis was conducted using G - power, version 3.1 (Faul et al., 2007; Schlechter, 2024). Results indicated that the minimum sample size needed to achieve statistical power of 0.95, at a significance criterion of $\alpha = 0.05$, will be $N = 130$. Therefore, at least 130 participants will be needed to obtain a high level of power to test all study hypotheses. Thus, sample size of $N = 240$ is proposed for the present study.

In the present study Purposive sampling and Stratified Random sampling will be used by the researcher. Purposive sampling technique will be used for selection of schools. Purposive sampling is essential in this context as it will allow for the deliberate selection of schools that encompass all three streams—Arts, Commerce, and Science by specifically targeting schools with the three academic streams of secondary stage. By using Stratified Random Sampling, the researcher will ensure that sampling frame is divided into distinct strata based on streams (Science, Arts, and Commerce) and gender (Boys and Girls). For this purpose, two schools [Twenty students will be selected from each stream (Arts, Science, and Commerce) of each class (XI and XII) resulting in sixty students per class.

This will give a total of one hundred twenty students per school and a combined total of two hundred forty students from both schools of Agra district] will be selected. It will enable the researcher to systematically compare errors in higher order thinking skills across different streams and gender, thereby facilitating a comprehensive understanding of potential differences or similarities in error patterns.

Sampling Procedure

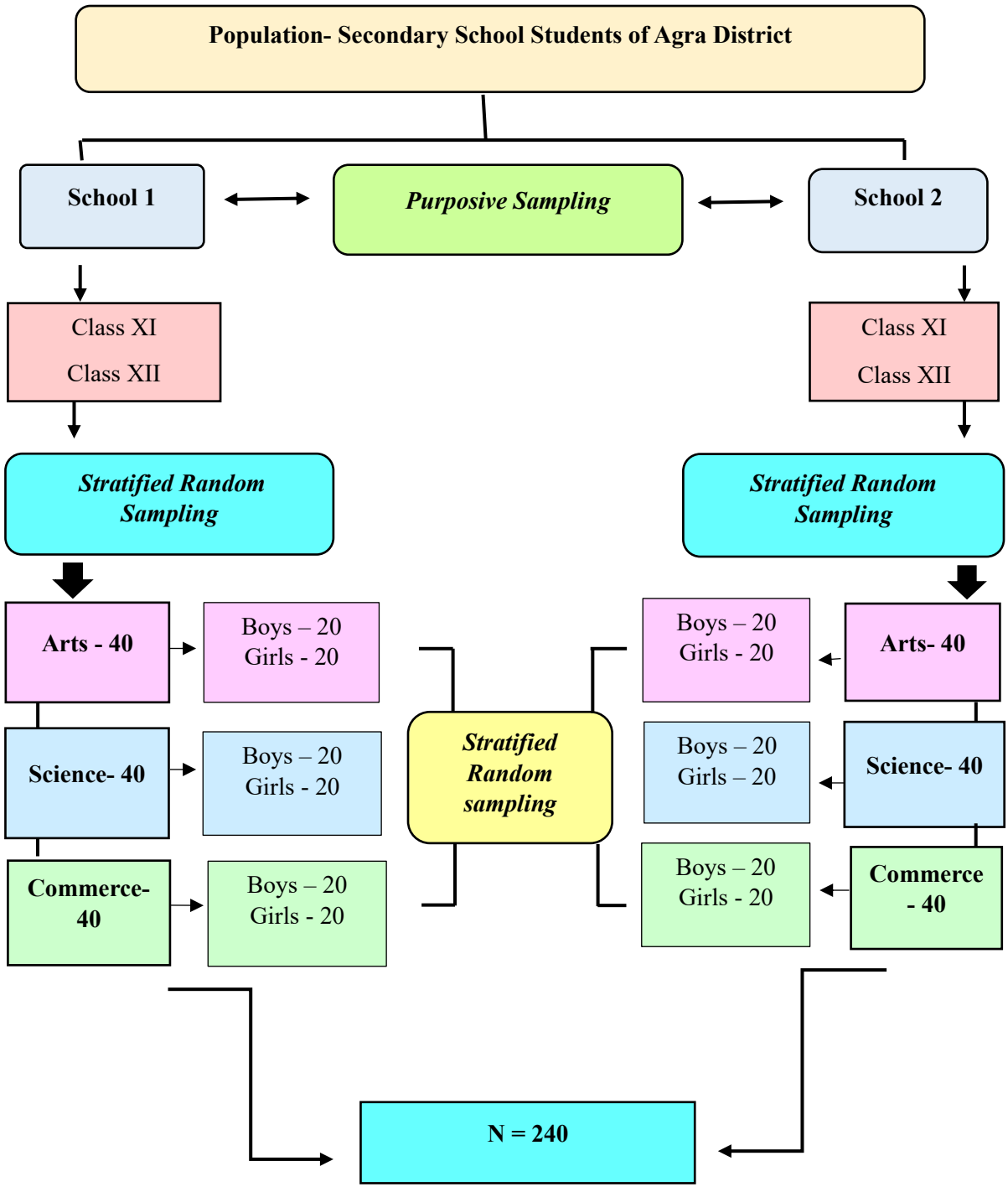

Figure 1. Sampling Procedure

Research Tool

The Higher Order Thinking Skills test focusing on the dimensions of Analyze, Evaluate, and Create as per Anderson and Krathwohl's revised taxonomy were reviewed. The "Ross Test of Higher Cognitive Processes" developed by Ross & Ross in 1976 was excluded as it only assesses the higher order thinking skills of students from fourth to sixth grade. The "Non-routine Problems Test" developed by Sartika &

Fatmanissa was used to assess Higher Order Thinking Skills Based Errors was rejected as it assesses errors of Trigonometric Function of students and not suitable for the study due to its narrow scope. The "Test of Higher Mental Ability in Science" by Sansanwal and Joshi was excluded because it emphasizes Application, Analysis, Synthesis, and Evaluation, but the dimension i.e. Creation is not covered. The "Non- routine Problems involving Higher Order Thinking Skills " developed by Anugrah et al. was excluded due to its application only on eighth grade students, while the Test of Identifying Errors in "Higher Order Thinking Skills" by Pasani & Suryaningsih was deemed inappropriate as it lacks validation by experts. However, these reviewed tools can become the basis for the tool being developed in this study.

Following self-constructed research tool will be employed for data analysis and interpretation-

Higher Order Thinking Skills Test: The researcher will construct a test to assess higher order thinking skills. The objective of this test will be to study the errors committed by students while solving problems based on Higher Order Thinking Skills. The questions will be based on dimensions of Higher order thinking skills such as analysis, evaluation and creation. It is proposed that the test will consist of a total of fifteen items, with five questions each from the dimensions of analyze, evaluate, and create. However, the final number of questions will be determined after a more comprehensive review of the literature and suggestions from experts. The test will be administered in both languages - English and Hindi. The test will be common for students of all the streams.

Statistical Tools

Both the Descriptive and Inferential Statistics will be used. In this research,

In Descriptive statistics, the researcher will employ ***Mean*** and ***Standard deviation***, the main reason behind descriptive statistics is to provide a concise summary of the samples and the measures done on a particular study.

In Inferential Statistics, the researcher will employ ***Two-Way ANOVA*** to assess any significant differences among the mean scores of various streams (arts, science, and commerce) and gender. If such differences are identified, the researcher will conduct a ***post-hoc test (t-test)*** to further examine the specifics.

In Graphical Representation, data will be presented in graphs.

Educational Implications

For students

This study will help students to understand ideas better, identify errors and ultimately improve learning outcomes (Bai et al., 2023). When students consistently make errors in their academic work, they frequently experience anxiety and frustration. The study will help students to identify higher order thinking skills based errors, which will boost their confidence and help them develop a more positive attitude towards the content/subject. (Niederle & Vesterlund, 2010). Higher Order Thinking Skills is frequently a predictor of success in a variety of academic activities and future career development. This study will help the students in their academic and professional ambitions in the long run by improving their understanding. Interventions that will develop on the basis of the error analysis of the supposed study will help students to rectify and reduce errors. By identifying disparities and similarities in error patterns influenced by different streams and gender efforts will be directed towards promoting fairness and equality in educational opportunities (Geverek et al., 2020). Based on supposed study, if error analysis is conducted on each and every subject that will be fruitful for the students.

For Teachers

Based on the research findings, teacher training and professional development programs will be designed to address the specific error patterns identified in study. By having empirical data of various errors such as comprehension error, transformation error, process error and encoding error in higher order thinking skills based problems, teachers will make more right decisions towards rectifying and reducing errors that positively impact student learning outcomes. This research will guide the teachers in modifying their teaching methods and strategies to address specific higher order thinking skills based errors identified among students. This study will empower teachers with the skills and strategies after identifying errors that are needed to support students in overcoming challenges while solving problems based on higher order thinking skills. By understanding the different types of error patterns which are influenced by different streams and gender teachers can differentiate their instruction to cater the diverse learning needs.

For Administrator

Administrators will utilize the research findings to make informed decisions regarding instructional

approaches, curriculum design, and resource allocation. The research outcome will contribute to long term strategic planning for the schools. Administrators can use the data on errors in higher order thinking skills based problems to set measurable goals towards enhancing students' proficiency in critical thinking, problem-solving, and analytical abilities etc. This research study will help administrators to suggest new assessment methods which target to assess higher order thinking skills of students. This strategic approach will facilitate the development of targeted interventions aimed at improving educational outcomes.

For Parents

The study will help parents to understand higher order thinking skills based errors that their children commit. This awareness enables them to find solutions and provide assistance and support in areas where their children may struggle (Sepang & Sirola, 2013).

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